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FEASIBILITY OF STRUCTURAL FOAM/CONCRETE BUILDING FOR THEATER OF--ETC(U)
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construction engineering research laboratory

TECHNICAL REPORT M-231
March 1978
Foam Material Application in Theater of Operations Construction

# FEASIBILITY OF STRUCTURAL FOAM/CONCRETE BUILDING FOR THEATER OF OPERATIONS USE

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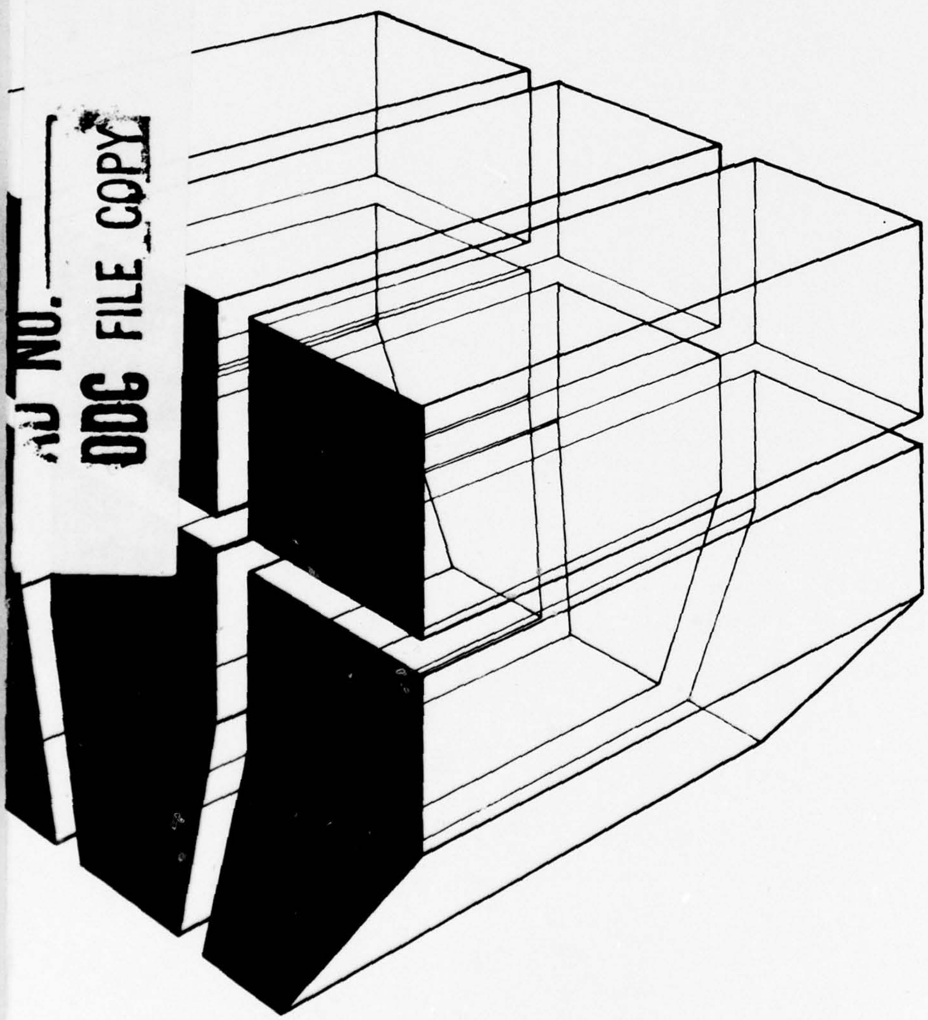

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This study was performed to assess the feasibility of using preformed polystyrene foam building blocks to construct shelters in noncombative areas of the Theater of Operations (TO).

A structure in which the principal wall material was polystyrene foam blocks was designed, constructed, and evaluated on the basis of logistics requirements, manpower time, required skill levels, and costs.

It was concluded that the polystyrene foam block building required less than half the man-hours and slightly lower skill levels than were necessary to erect a similar-sized Army


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Facilities Components System timber building. However, the foam block building has a 75 percent greater shipping volume in the expanded form, and a 300 percent greater materials cost. Based on these conclusions, it is recommended that the foam block system be used in the TO only if the expansion and molding equipment is established within the area of planned usage.

# FOREWORD

This investigation was conducted for the Directorate of Facilities Engineering, Office of the Chief of Engineers (OCE), under RDT&E Program 6.27.02, Project 4A762719AT41, "Research for Base Development in the Theater of Operations"; Task 08, "Base Development Design and Construction"; Work Unit 002, "Foam Material Applications in Theater of Operations Construction." The OCE Technical Monitor is Mr. Ed McWhite.

The work was performed by the Construction Materials Branch (MSC), Materials and Science Division (MS), U.S. Army Construction Engineering Research Laboratory (CERL). Mr. Harvey Barrett's contributions to this work are gratefully acknowledged.

COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director. Dr. G. R. Williamson is Chief of MS, and Mr. P. A. Howdyshell is Chief of MSC.

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## FIGURES



## TABLE

# FEASIBILITY OF STRUCTURAL FOAM/CONCRETE BUILDING FOR THEATER OF OPERATIONS USE

# 1 INTRODUCTION

### Background

The Army Facilities Components System (AFCS) is a military engineering support system for commanders and military planners to use in selecting facilities and installations for military theaters of operations (TO).[1] Foamed plastic materials show potential for augmenting the materials used in the AFCS. They offer excellent strength-to-weight relationships, possess the best thermal insulating properties available, and can be readily erected at a low cost.[2]

### Objective

The objective of this study was to assess the feasibility of using preformed polystyrene foam building blocks for constructing shelters in noncombative areas of the TO. This study is one part of an overall program investigating the use of low-density plastic foams as construction materials in the TO.

### Approach

A structure in which the principal wall construction material was polystyrene foam blocks was designed, constructed, and evaluated on the basis of logistics requirements, manpower time, required skill levels, and costs.

### Mode of Technology Transfer

The information contained in this study, if adopted for use by the Army, will impact on the following technical manuals: TM 5-301-1, 2, 4, *AFCS Planning: Temperate, Tropical and Desert Regions*, TM 5-302-1, 2, *AFCS Design*, and TM 5-303, *AFCS Logistic Data and Bills of Material*.

[1] AR 415-16, *Army Facilities Components System* (Department of the Army, 1 October 1975).

[2] *State of the Art Studies on the Development of Industrialized Housing in the United States as Related to the Role of the Civil Engineer*, Project Number 714 (Texas A&M Research Foundation, 1971).

# 2 POLYSTYRENE FOAM BUILDING SYSTEM

### Development

Structural Foam, Inc. has developed and patented a foam building system that can be used to erect single and multistory buildings.[3] Tests of building components conducted by independent testing laboratories for the company have shown a performance level in excess of the Federal Housing Administration (FHA) design codes required for residential housing.

CERL contracted with Structural Foam, Inc. to provide walls, doors, window frames, trim, and gable ends for a 624 sq ft (58 $m^2$) structural foam building as shown on the floor plan in Figure 1.[4]

### Erection

The building was erected using polystyrene foam modules (Figure 2) consisting of foam blocks 6 in. wide by 12 in. high (152 by 305 mm), with lengths ranging up to 20 ft (6.1 m). The foam was expanded and preformed into blocks in a manufacturing plant, using heavy metal equipment and presses. The blocks were formed with 3 in. (76 mm) diameter holes on 6 in. (152 mm) centers through the 12 in. (305 mm) direction (Figure 3).

At the site, the blocks were formed into modules with the holes aligned. The entire structure was built on a conventional concrete block foundation and wood joist, plywood floor system. A channel block used for the top course of the foundation was filled with concrete reinforced with two No. 3 reinforcing bars. No. 3 dowels were placed at 24 in. (610 mm) on center throughout the length of the foundation to match every fourth hole in the wall modules. A No. 3 reinforcing bar was placed in the holes where a dowel had been set and the holes were filled with sand mortar to form a reinforced concrete stud every 24 in. (610 mm) throughout the entire building exterior. The interior partitions were constructed in the same manner, except there was no concrete block foundation under them and thus no dowel to tie the stud to the foundation.

[3] U. S. Patent, 3,566,568 to Structural Foam, Inc.

[4] Contract DACA 88-74-0054, CERL, 18 June 1974.

Figures 4 through 7 show the building in various construction stages. Door and window units were installed as the walls were erected (Figures 8 and 9). Figure 10 shows the arrangement of the mortar studs in the wall systems. A mortar beam reinforced with two No. 3 bars was cast around the entire top perimeter of the walls as indicated in Figures 11 and 12. Foam drinking cups were inserted in the tops of the holes where concrete was not desired to form studs (Figure 11). Mortar was placed manually in the model building, although a plaster pump is normally used for this purpose.

The roof system consisted of preconstructed wood trusses (Figure 13) set on 24 in. (610 mm) centers and secured to the walls by metal anchors that had been set in the beam at the top of the walls. Nailer strips were attached to the trusses at 18 in. (457 mm) intervals (Figure 14). Galvanized corrugated steel was nailed to the strip and a ridge cap secured along the ridge line. Corrugated steel roofing was used, since it is commonly used in the TO.

The underneath side of the roof was insulated by spraying it with a 2 in. (51 mm) minimum thickness of polyurethane foam. Adhesion of the foam to the metal and nailer strips was excellent. The ambient temperature ranged from 30°F (-1°C) to 40°F (4.4°C) during foam application, but presented only minor problems by retarding the foaming of the initial deposition of spray. Subsequent sprayed layers foamed normally. After the foam was applied, a 1/4 in. (6.35 mm) minimum thickness of gypsum plaster was sprayed over it to act as a fire-resistant coating. The plaster adhered well, since the foam was sufficiently rough to permit mechanical locking.

The building interior was finished by applying gypsum wallboard to the walls and ceilings of two rooms, the corridor, and the bathroom; the other two rooms were finished with paneling on the walls and lattice suspended ceilings. Nailers were installed along the top and bottom of the walls to attach the gypsum board and paneling. An adhesive compatible with the polystyrene foam was also used to adhere the sheets to the wall. Prior to application of the finish, grooves for electrical wires were routed in the foam; however, the empty 3 in. diameter holes in the walls could also be used for running utility lines.

Floor coverings consisted of linoleum tile in the rooms with gypsum wallboard, and low-pile "indoor-outdoor" carpet in the rooms with paneled walls.

The exterior walls were finished with aluminum siding.

# 3 EVALUATION

### Performance

The building has been occupied by a solar heating and cooling facility (Figures 15 and 16) for 1 1/2 years and is performing well. The high "R" value* of the foam walls (18.5), as compared to that of conventional construction with 3 1/2 in. "batt insulation" (9.71), permitted the use of a lower capacity energy collection and storage system.

### Logistics

The shipping volume of the building materials was about 750 cu ft (21.3 $m^3$). A similar AFCS building⁺ occupies about 420 cu ft (11.76 $m^3$). The manufacture of polystyrene involves a dual thermal process in which the material undergoes a total expansion of up to 60 times its original volume. The material is formed during the second expansion process, which requires extensive heating and molding equipment. The shipping volume of the materials required for the building in this study can be reduced by 65 percent if this process is accomplished on equipment erected in the TO. (The appendix describes the process.)

### Man-Hours and Skill Levels

Erection time for the building was 248 man-hours (Table 1), compared to a planned time of 540 man-hours for an AFCS building of the same size. The walls can be erected by unskilled laborers, but foundation, roofing, and finish work require the same skill levels as a typical AFCS structure.

### Costs

The cost of materials for the 624 sq ft (58 $m^2$) foam/concrete building was \$4150, compared to \$972

*"R" is the resistance to heat transfer through a material or material system. It is the reciprocal of the "K" (conductance) value which is stated in Btu/sq ft/in. thickness per hour. The metric equivalent of K would be 5.67 $\frac{\text{watts}}{\text{meter}^2\ {}^\circ\text{K}}$ and of R $(.176 \times 10^{-1})\frac{\text{meter}^2\ {}^\circ\text{K}}{\text{watt}}$.

⁺AFCS facility number 722121, Qtrs, Female Employees, 20′ × 30′ Wood, was selected for comparison, since area and plan are so similar to CERL foam/concrete building.

**Table 1**
**Man-Hours Required to Erect Model Structure**

| | |
|---|---|
| Foundation/Floor | 32 |
| Setting Wall Modules | 16 |
| Concrete Studs and Beams | 52 |
| Roof Trusses (Building and Installation) | 24 |
| Metal Roof Placement | 16 |
| Foam Spray Insulation | 16 |
| Plaster Spraying | 32 |
| Interior Finish, Including Wiring | 64 |
| TOTAL | 248 |

for a comparable-area AFCS building. Cost per square foot of floor space for the CERL building was $10.79, including all work except the solar heating/cooling plant. By comparison, the Texas A&M study showed a 1200 sq ft (111.5 $m^2$) house being completed in 400 man-hours in 8 working days from initial grading to readiness for occupancy. Cost per square foot for the building was $8.64, including site preparation, foundation, erection, and finishing work. This difference is attributable to the labor and overhead rates being higher at CERL in 1973-74 than were common in 1970 in the construction industry.

**Problems Encountered**

Problems encountered in constructing the building were as follows:

1. Pouring mortar to form the studs caused buckling of the exterior finish and breaking of the unsupported interior face of some foam blocks in three areas near the bottom of the wall (Figure 17).

2. Door frames were distorted during the building process and had to be reworked before interior doors could be hung.

3. Application of nailer strips was time consuming. Nailer strips should be included in selected polystyrene blocks so that interior finish panels could be more easily applied.

4. Use of foam for partition walls was expensive and did not provide a good backing for paneling. Conventional walls for partitions would be somewhat less expensive, and would form a better backing.

# 4 CONCLUSIONS AND RECOMMENDATIONS

1. The polystyrene foam block building described in this report required less than half the man-hours necessary to erect a similar-sized AFCS timber building.

2. The insulation value of the foam walls, R = 18.5, is far superior to that of plywood/stud/batt insulation walls, R = 9.71.

3. The shipping volume of the polystyrene building as presently constructed is 75 percent greater than that required for a similar AFCS structure; however, if the expansion and molding equipment is available in the TO, the shipping volume can be reduced by 65 percent.

4. Required skill levels are slightly lower than those for a comparable AFCS building.

5. The material costs for the polystyrene building are over 300 percent greater than the costs of a comparable AFCS timber building.

It is recommended that the polystyrene foam block building construction system described in this report be used in the TO only if the expansion and molding equipment is established within the area of planned usage.

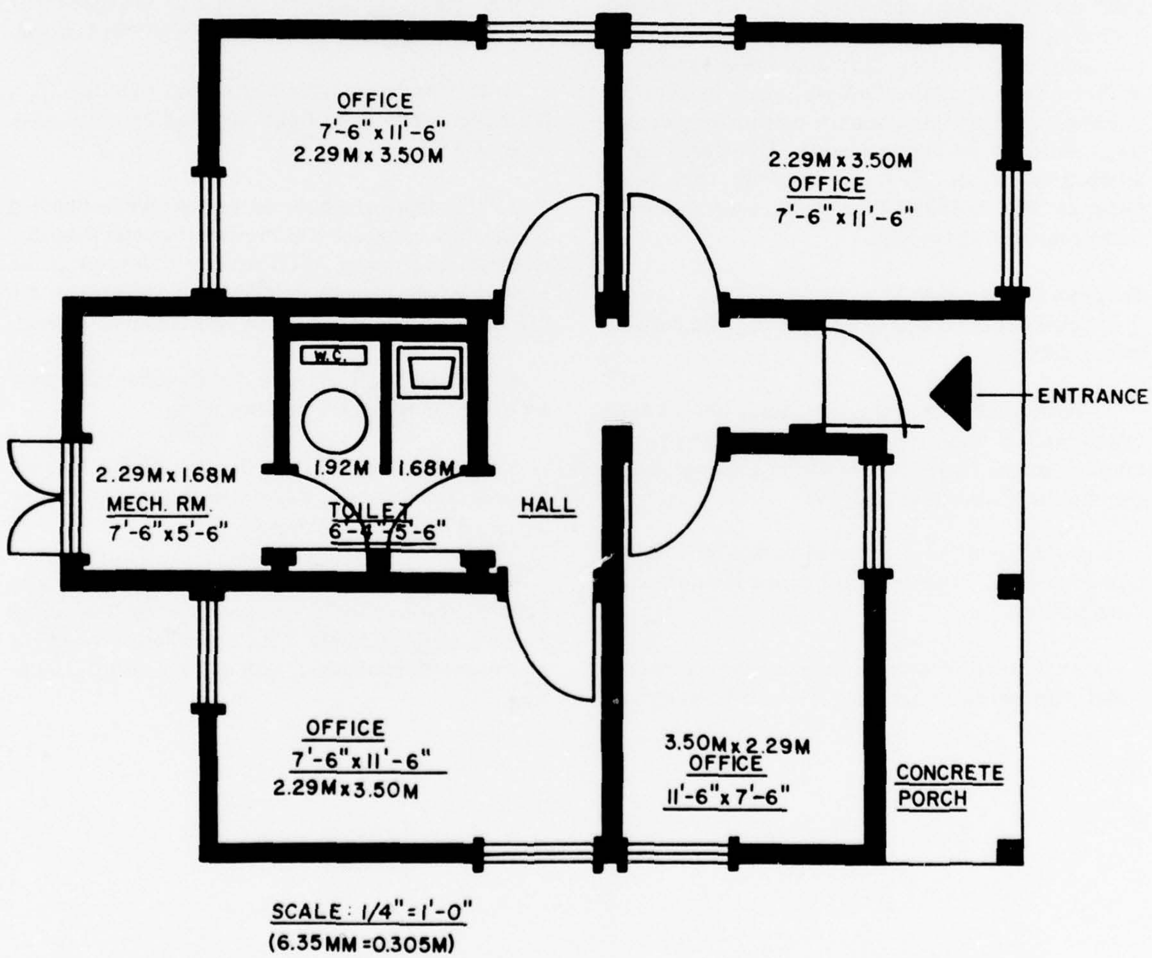


**Figure 1.** Plan of model structure.

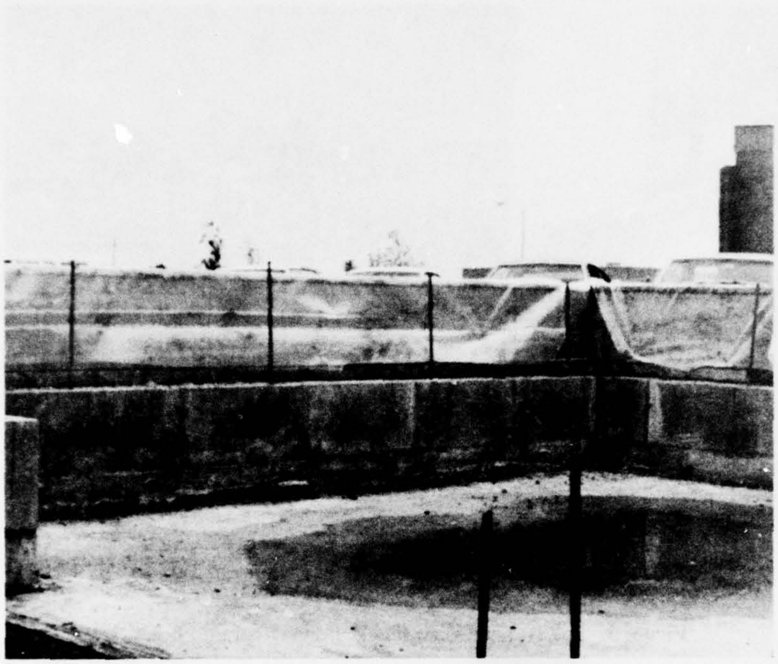

**Figure 2.** Floor and foundation.

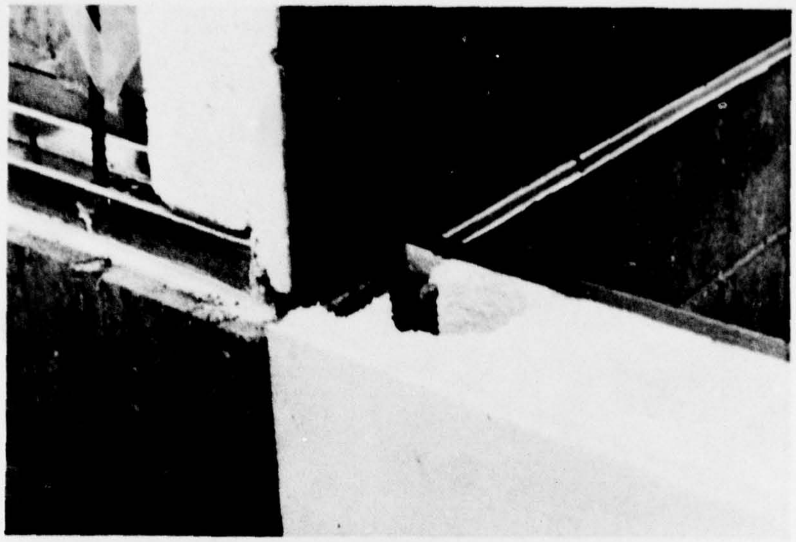

**Figure 3.** Polystyrene foam block showing column holes.

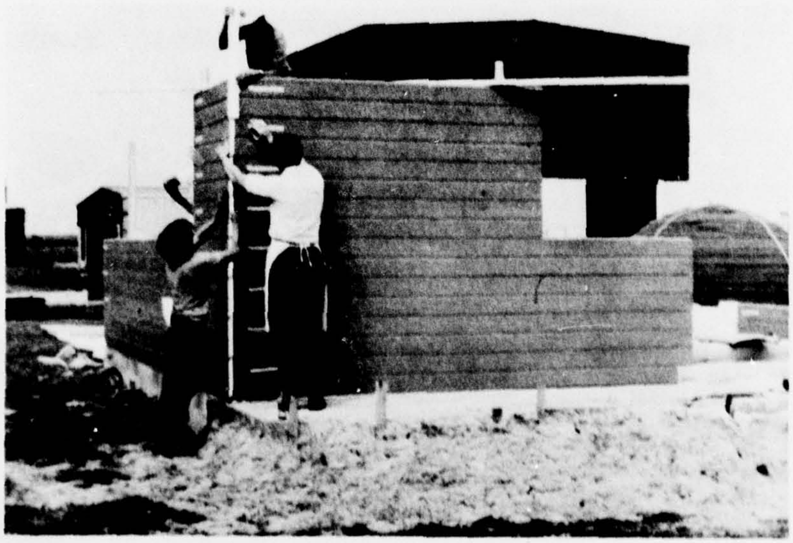

**Figure 4.** Erection of walls.

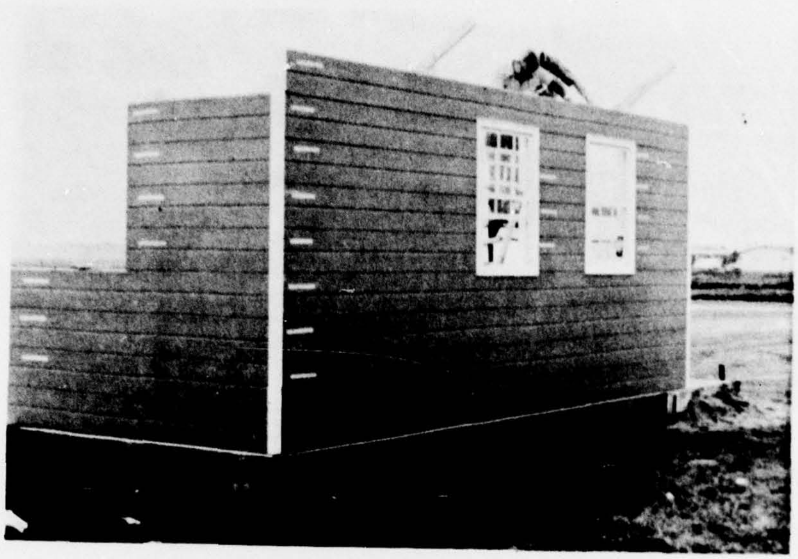

**Figure 5.** Erection of walls.

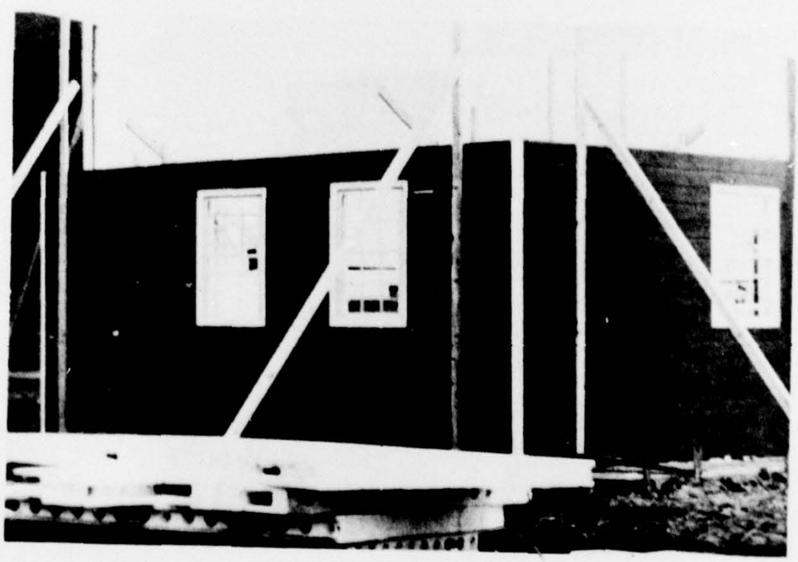

**Figure 6.** Erection of walls and bracing.

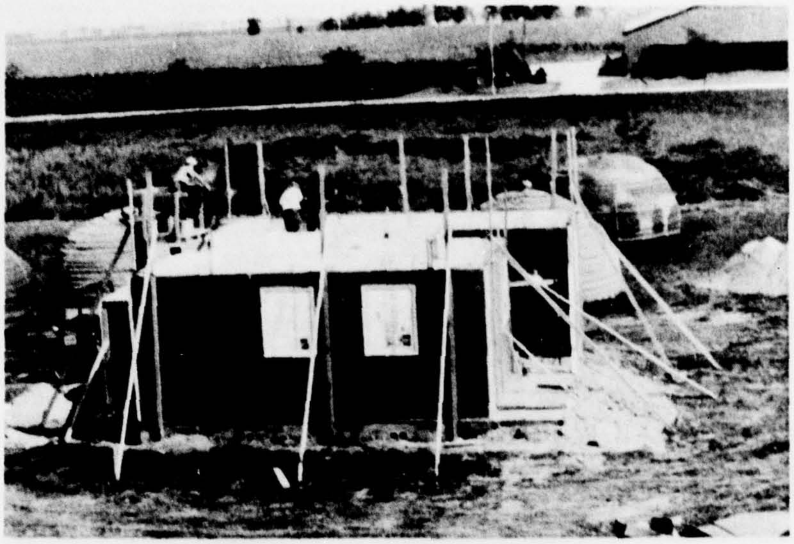

**Figure 7.** Completely erected exterior and interior walls including bracing.

**Figure 8.** Door unit in utility room.

**Figure 9**. Door unit, detail.

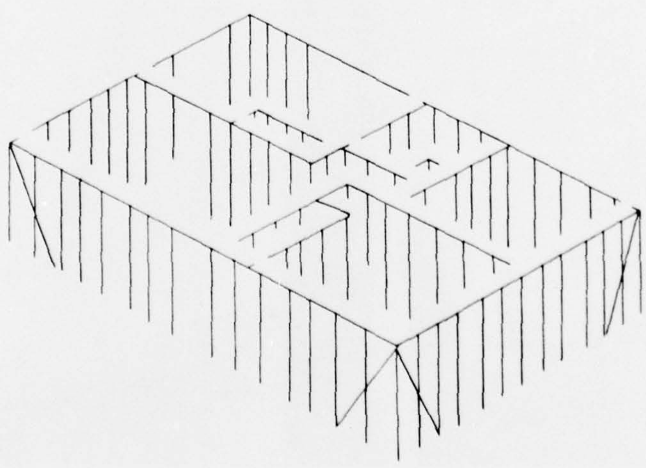

**Figure 10.** Location of concrete studs.

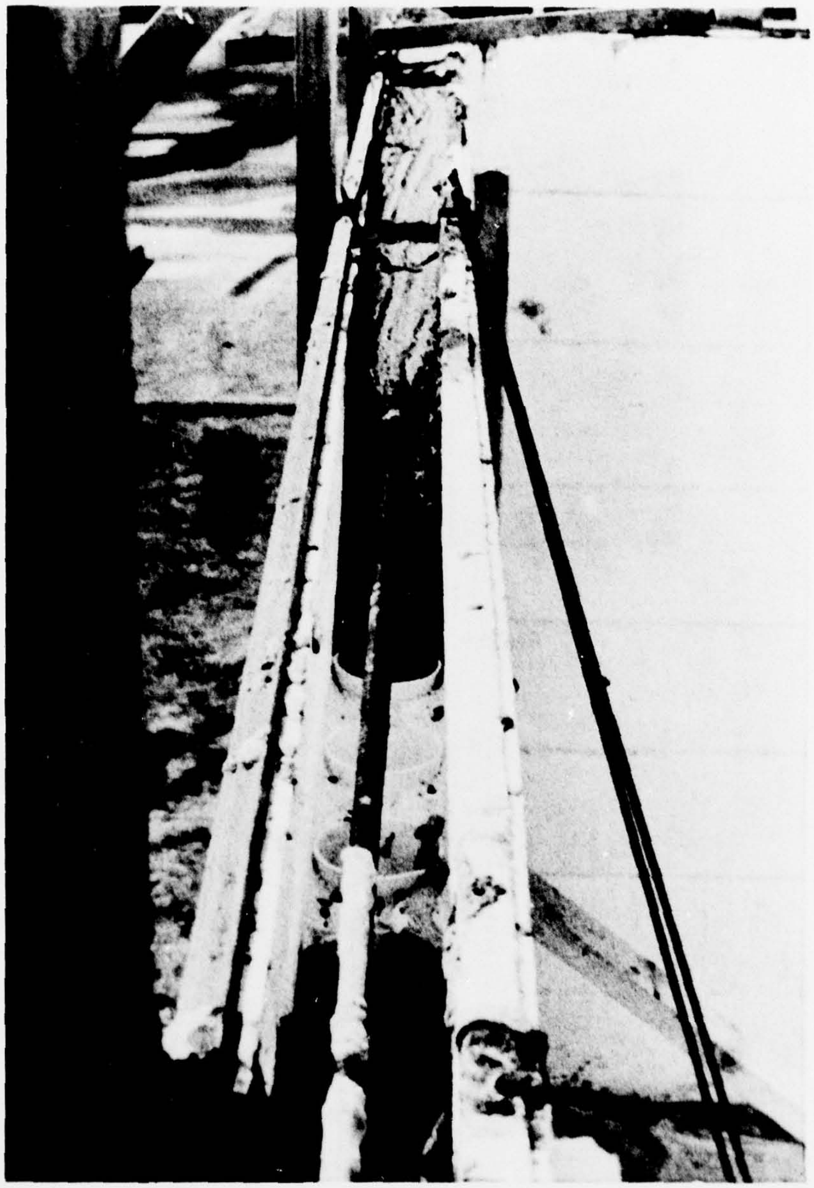

**Figure 11.** Mortar columns and reinforced beam.

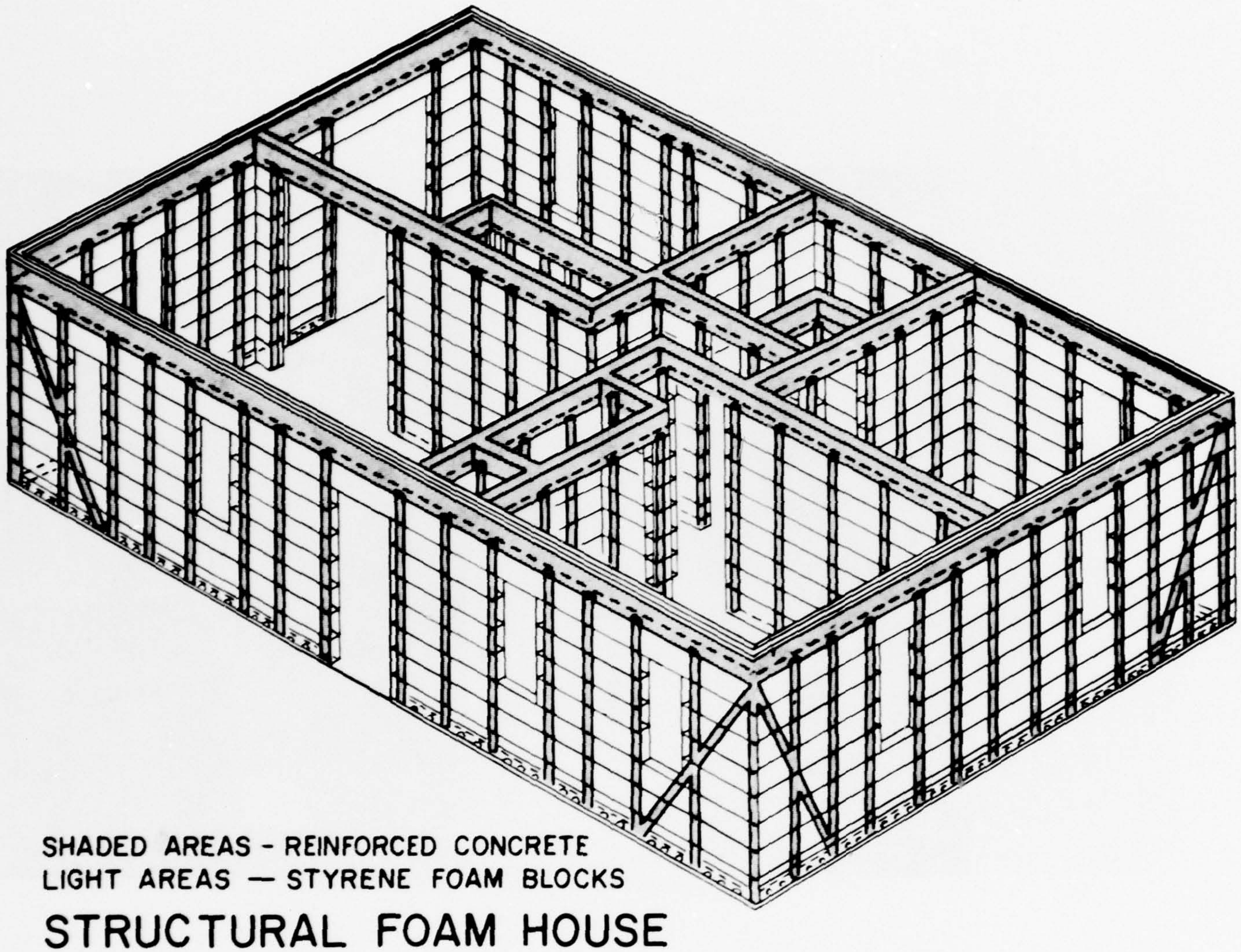


Figure 12. Arrangement of reinforced concrete and styrene foam blocks.

**Figure 13.** Wood truss roof support system.

**Figure 14.** Nailer strips on roof trusses.

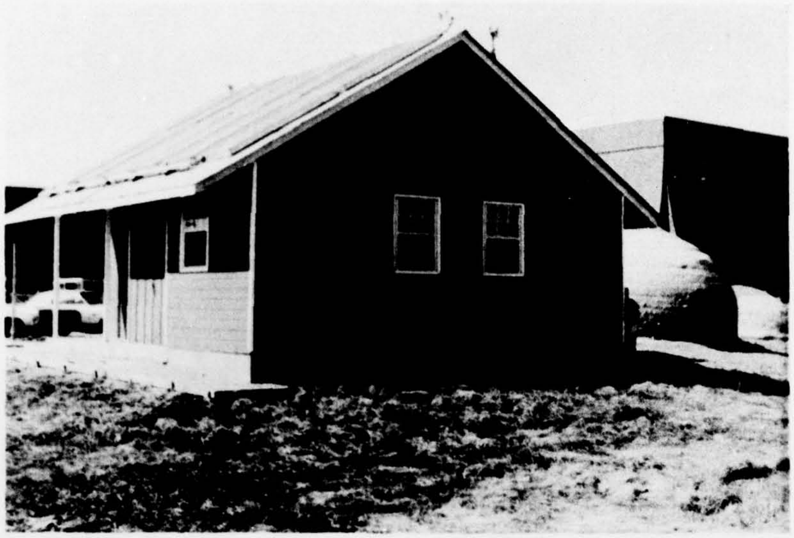

**Figure 15.** Completed structure with collector panels on south-facing roof.

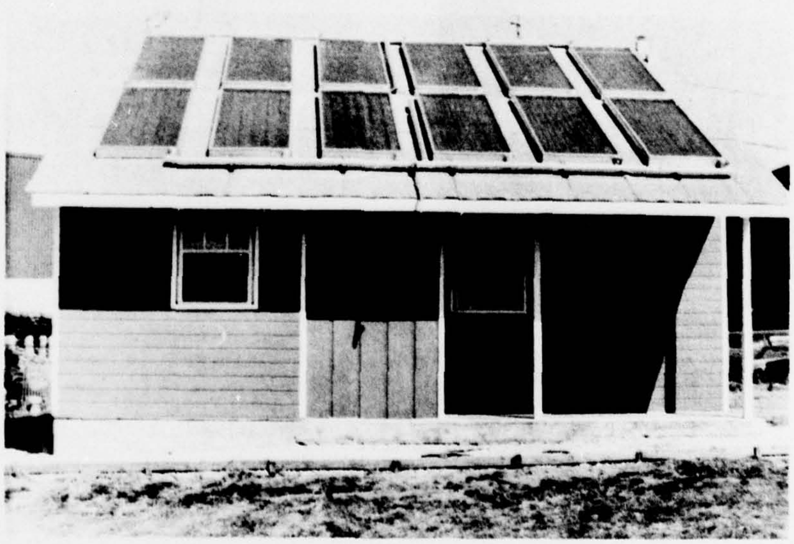

**Figure 16.** Front view of structure showing collector panels.

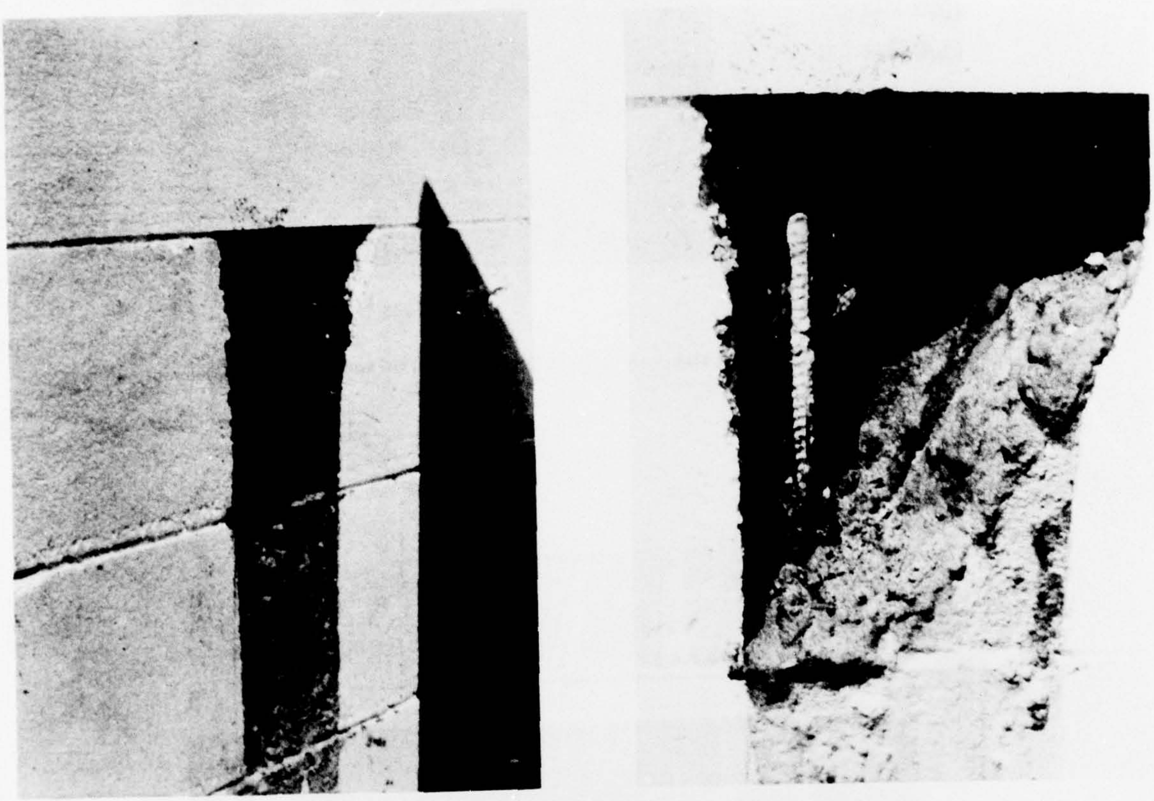

**Figure 17**. Foam broken by mortar weight.

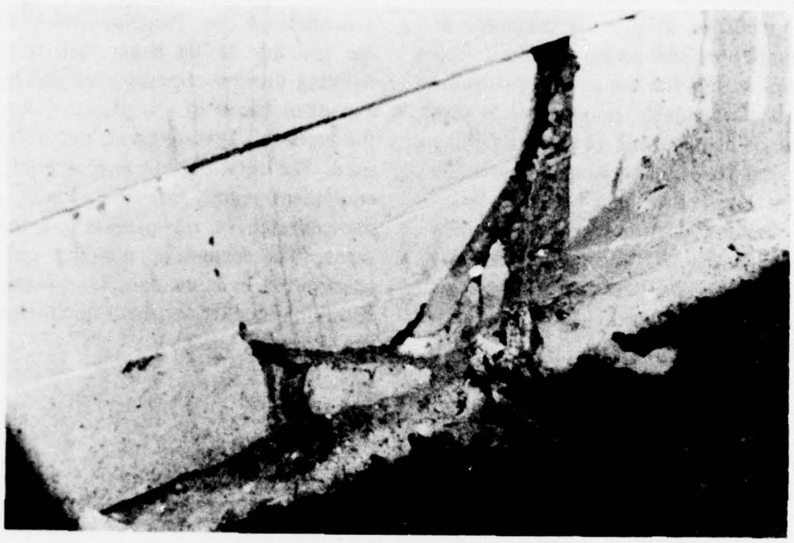

**Figure 17.** (Cont'd)

## APPENDIX: MOLDING OF POLYSTYRENE

Polystyrene is an inexpensive plastic, commercially available in large quantities. It is easily processed at relatively low temperatures and pressures, and its solubility characteristics permit the use of many solvents as expanding agents. Expandable polystyrene is produced in the form of free-flowing beads resembling *table salt, symmetrical shapes, and strands containing* an integral blowing agent such a n-pentane. When exposed to heat without restraint, these particles expand from a bulk density of 35 lb/cu ft (0.99 $m^3$) to as low as 0.25 lb/cu ft (0.007 $m^3$). When used for molding products, the particles are held to a minimum density of 1.0 lb/cu ft (0.028 $m^3$).

Molding expandable polystyrene beads is a two-stage process. First, the virgin beads are pre-expanded to the approximate desired density by the application of heat, usually in the form of steam. The process is a continuous one. Pre-expanded beads are allowed to age and dry before being used to mold shapes. The molding process requires a second heating of the pre-expanded beads in a confined space. Again, steam is the preferred heating agent, but other methods can be used. The total process is completely defined and the equipment readily available. Figure A1 is a diagrammatic sketch of the process and the required equipment. The complete molding operation could be transported in a standard tractor-trailer unit, with an additional facility provided for storage and aging of the pre-expanded beads.

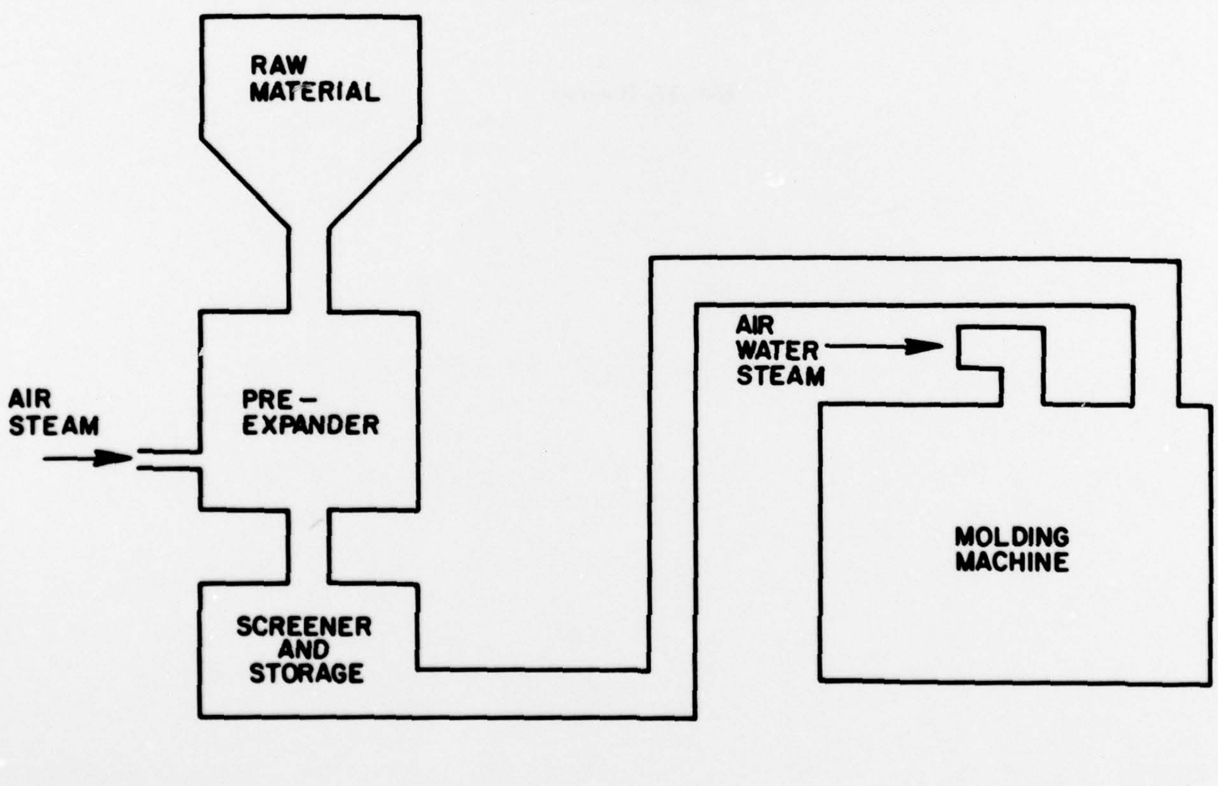


**Figure A1.** Diagrammatic sketch of typical expandable polystyrene molding operation.

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Smith, Alvin.
Feasibility of structural foam/concrete building for theater of operations use. - Champaign, IL. : Construction Engineering Research Laboratory ; Springfield, VA. : available from National Technical Information Service , 1978.
22 p. : ill. ; 27 cm. (Technical report - Construction Engineering Research Laboratory : M-231)

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